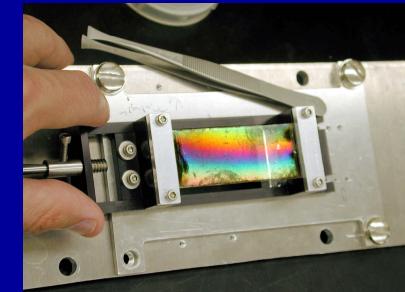
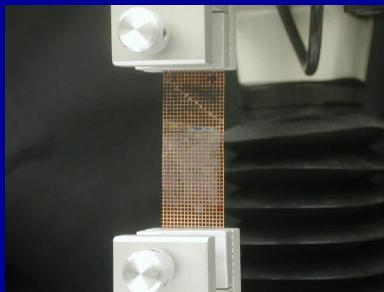
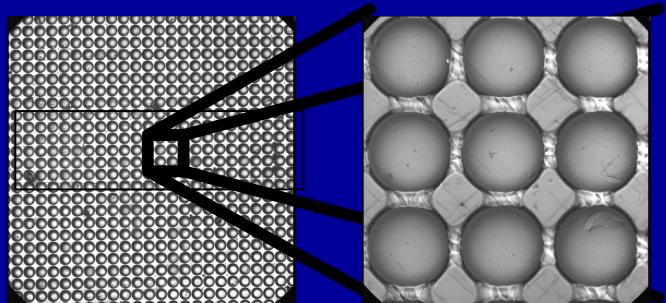




# *Adhesion and Mechanical Properties*



**C. Stafford, C. Davis, K. Beers, C. Harrison,  
R. Song, A. Forster, A. Chiche, M. Chiang,  
A. Karim**

9.12.02

# *Adhesion & Mechanical Properties*



- Combinatorial Adhesion
  - (1) Multilens Combinatorial Adhesion Test (MCAT)

A. Crosby	C. Davis
C. Stafford	A. Forster

2+ yrs
  - (2) Combinatorial Peel Test

R. Song	A. Crosby
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1 yrs
- Mechanical Properties
  - (3) High-Throughput Modulus

C. Harrison	C. Stafford
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6 mo.
  - (4) Combinatorial Fracture

K. Beers	A. Crosby
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6 mo.

# Adhesion



Need:

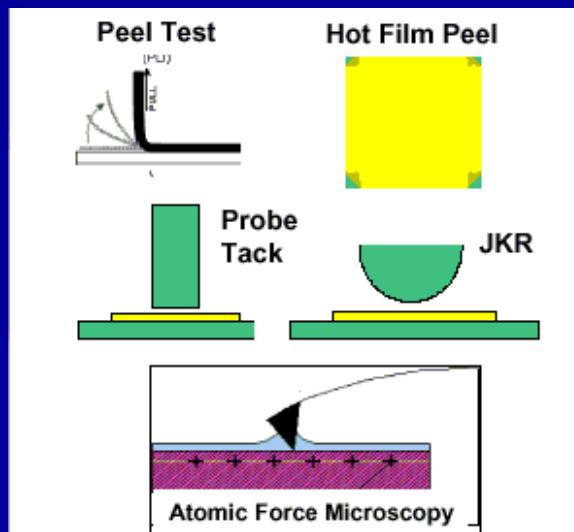
- ☛ Develop multivariable methodologies to quantitatively probe the adhesive strength at polymeric interfaces.

- ☛ Office Supplies
  - ☛ 3M Scotch Tape, Post-it Notes, PSA
- ☛ Electronic Packaging
- ☛ Paints and Coatings
- ☛ Biomedical and Biological Adhesion

- ☛ How does one measure adhesion / tack?

- ☛ What forces come into play?

- ☛ van der Waals interactions
- ☛ covalent bonds
- ☛ entanglements
- ☛ electrostatic
- ☛ dissipative processes

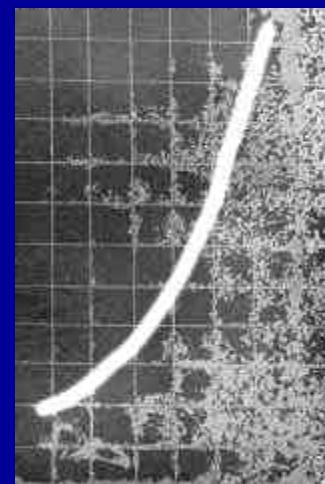
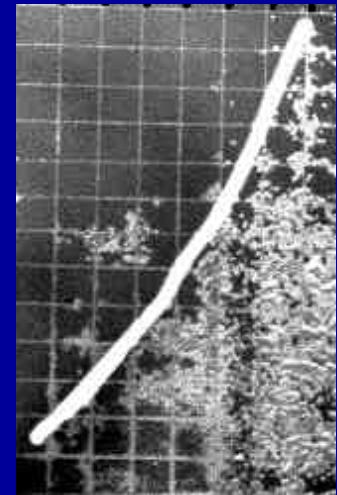
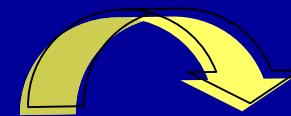
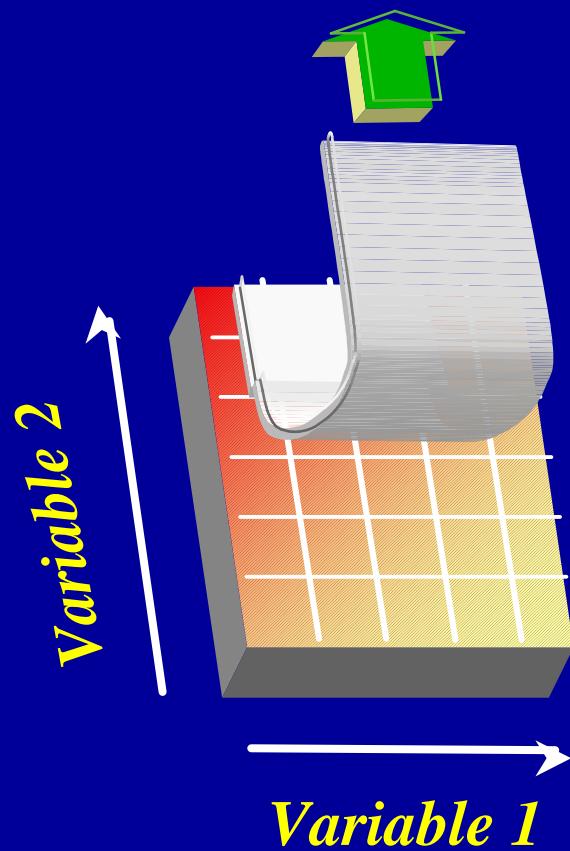


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# *Adhesion/Debonding*



## 180° Peel Test on Combinatorial Libraries

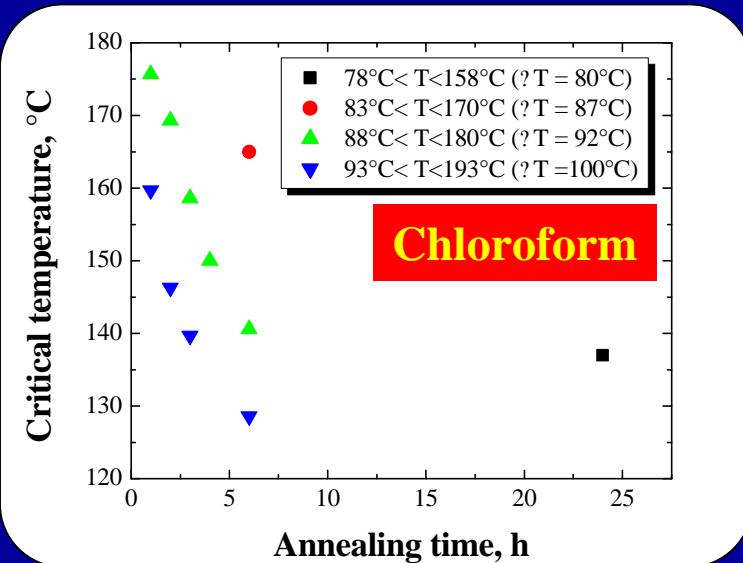
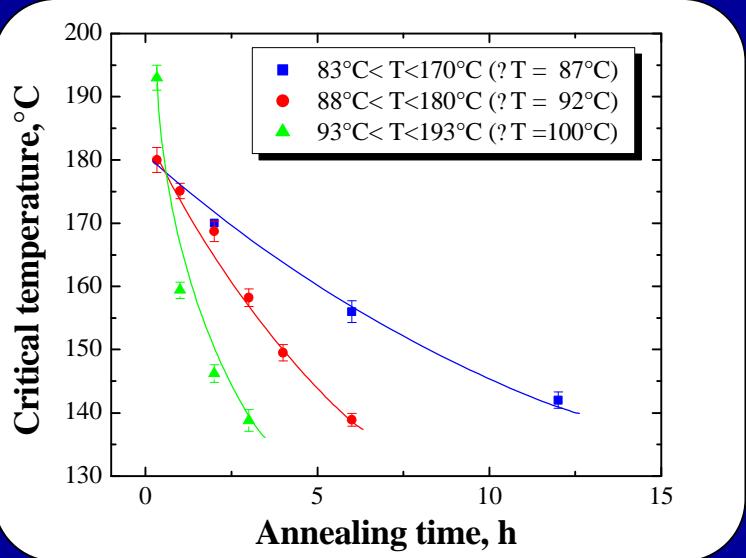


R. Song

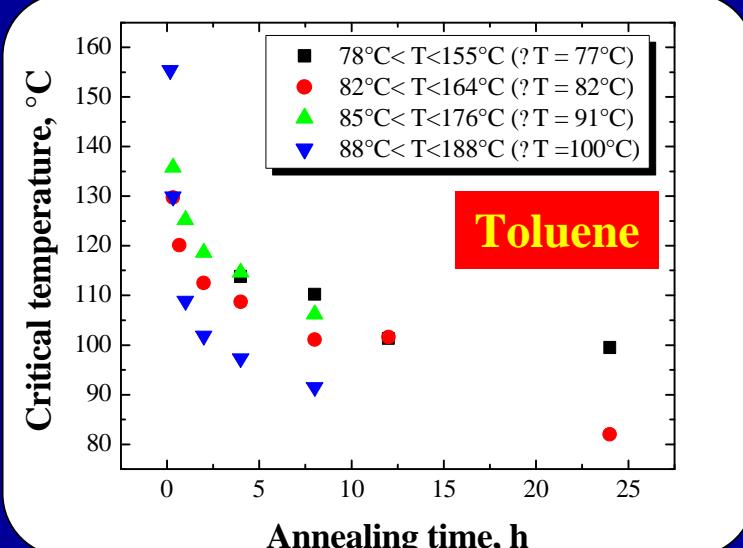
9.12.02



# Adhesion/Debonding



☞ We can evaluate processing conditions on the adhesive failure of polymer films.



# *Adhesion/Debonding*



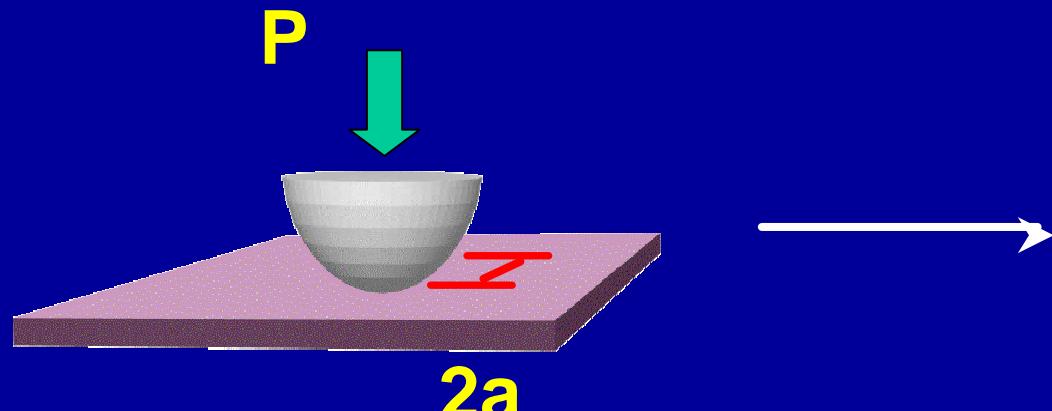
## Future Directions FY03

- ✉ Continue studying affects of processing history:
  - ✉ annealing temperature
  - ✉ annealing time
  - ✉ residual solvent effects
- ✉ Move into metal/polymer adhesion.
- ✉ Examine typical commercial photoresist.
- ✉ Explore model PSA system in conjunction w/ Formulations Group.
- ✉ Further develop simulations effort to construct predictive models of adhesive failure.

# Multilens Contact Adhesion Test



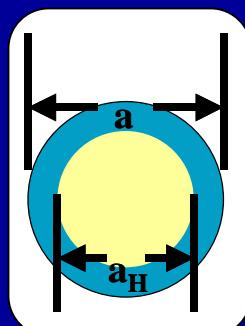
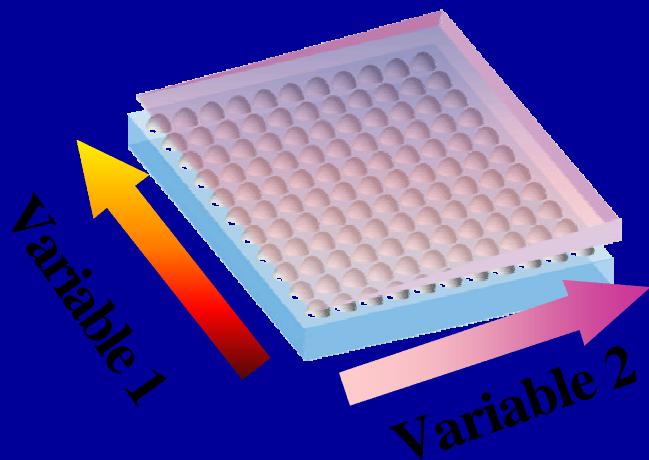
Classical JKR Approach



$$G \approx \frac{3(P' - P)^2}{32\pi E a^3}$$

Johnson, K.; Kendall, K.; Roberts, A.  
*Proc. R. Soc. Lond. A.* 1971, 324, 301.

Combinatorial Approach



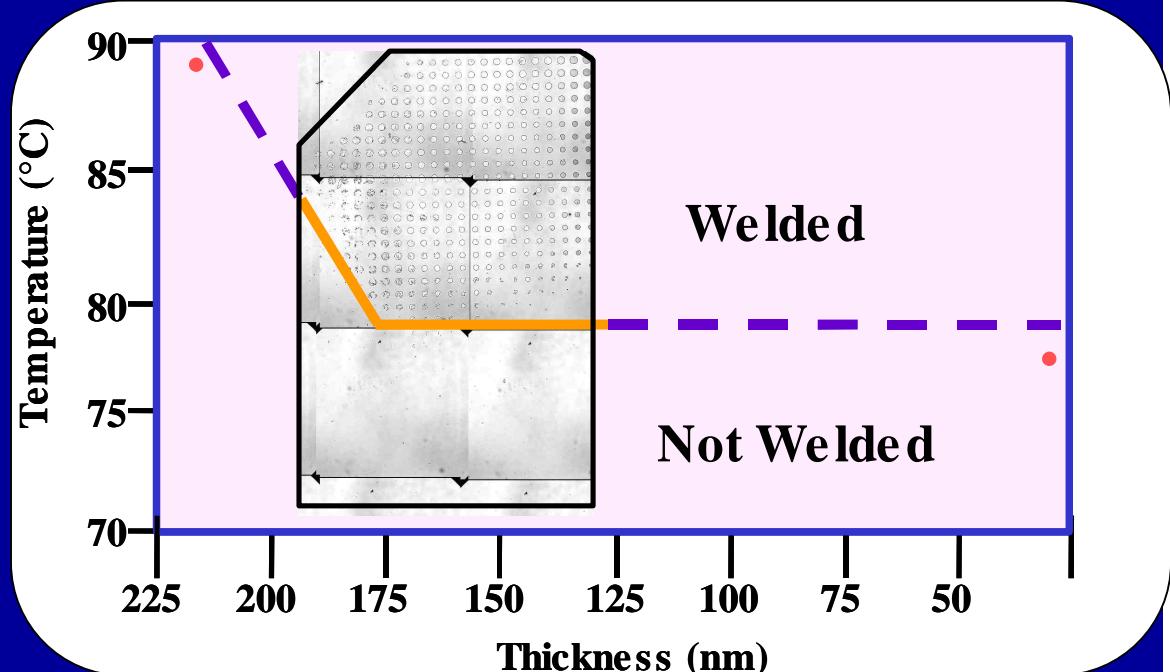
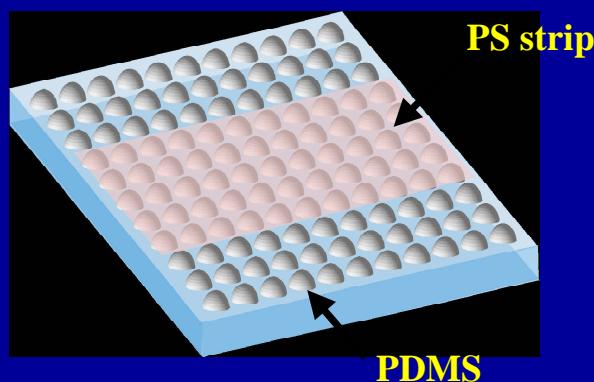
$$G \approx \frac{2E^{3/2} H^{3/2}}{3\pi a}$$

Crosby, A., et al., *J. Poly. Sci. Part B: Polymer Physics*, to be submitted.

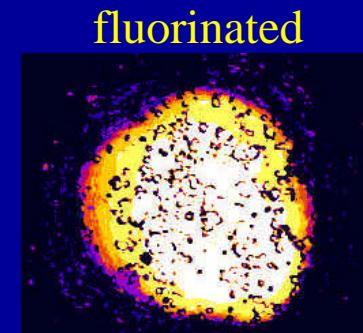
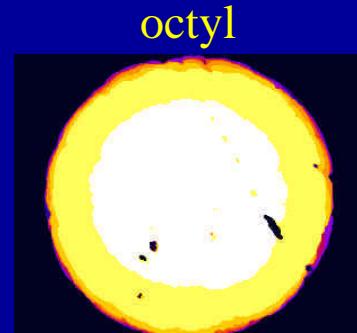
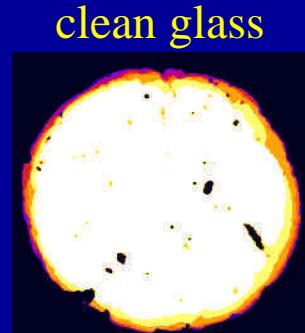
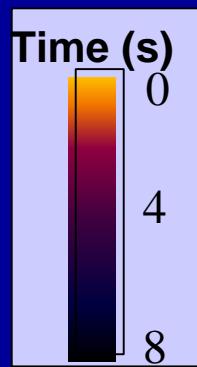
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## Validation Experiments:

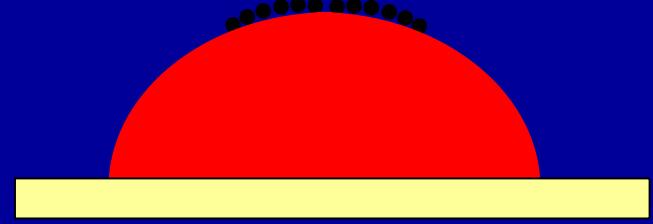


## Dynamics of Adhesion:

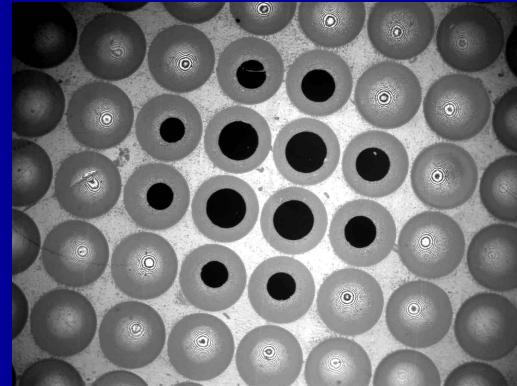
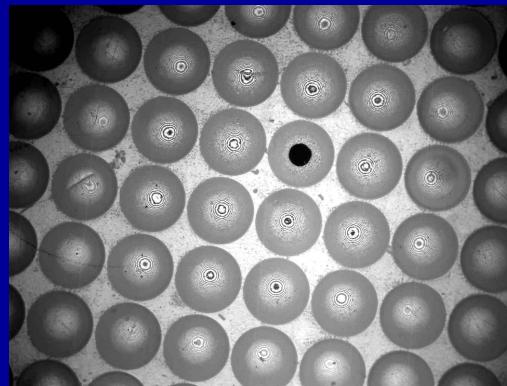
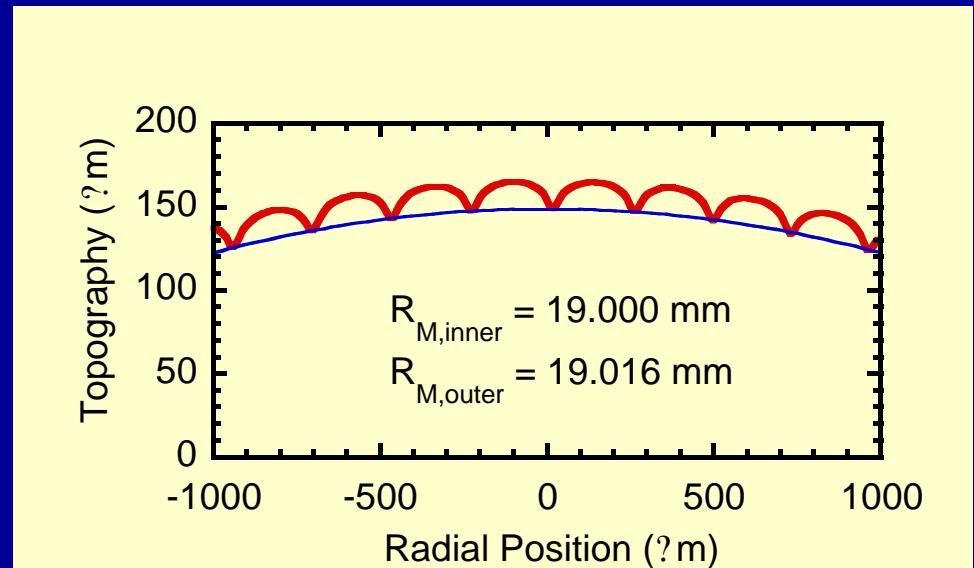


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# MCAT



Stretched ?Lens on PDMS Macrolens



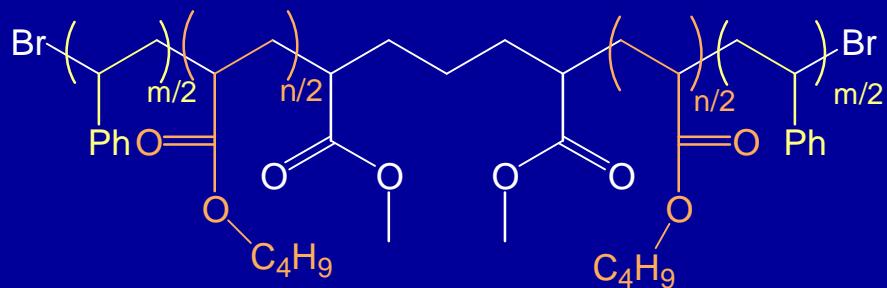
?h ~ 1 ?m  
explore strain gradients

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## Future Directions FY03

- ✉ Demonstrate MCAT on some practical systems.
- ✉ Hold NCMC Meeting on Adhesion & Mechanical Properties.
- ✉ Explore model PSA system in conjunction w/ Formulations Group.
- ✉ Continue to hone MCAT (i.e. temperature gradient, tip/tilt).
- ✉ Explore crosslink density vs. surface energy via adhesion.
- ✉ Study polymer/metal adhesion.
- ✉ Develop test methodology(s) for weak force adhesion.
- ✉ Develop methodology for adhesion on rough surfaces.



**p(S-b-nBA-b-S):**  
 $M_n = 105,000$   
 $M_w/M_n = 1.08$

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# Mechanical Properties

Need:

❖ Develop simple yet reliable, high-throughput techniques by which material properties can be measured.

❖ Modulus

❖ Strength

❖ Viscoelasticity

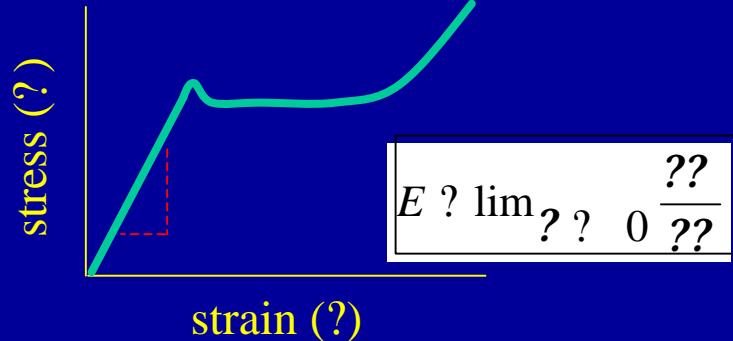
❖ Creep

❖ Toughness

❖ Crazing / Fracture

etc.

Who Cares?



$$E ? \frac{?}{?}$$

$$G ? \frac{E}{2(1??)}$$

$$K ? \frac{E}{3(1?2?)}$$

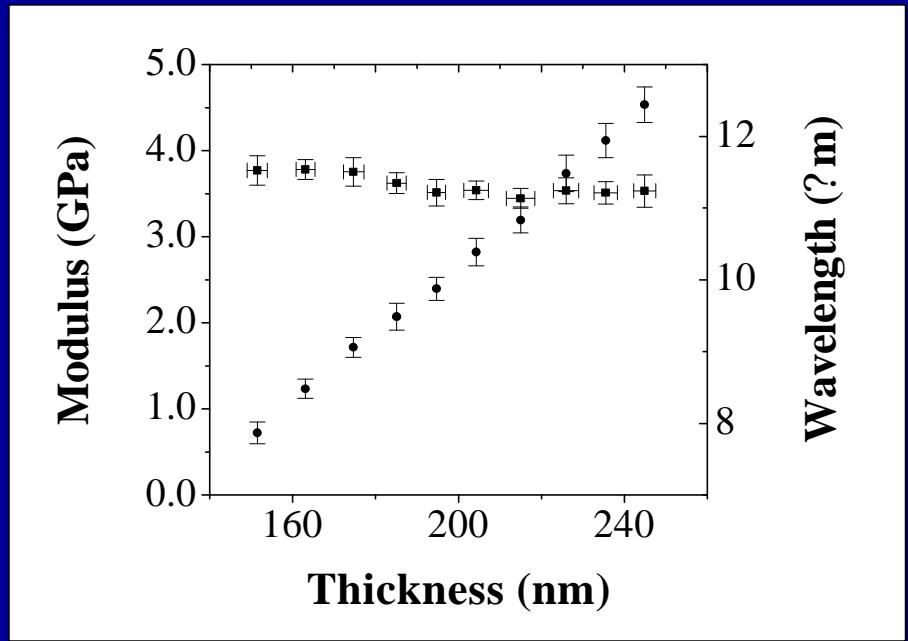
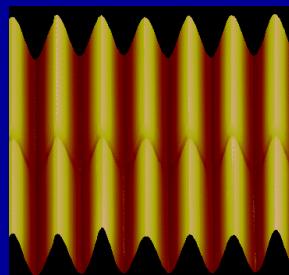
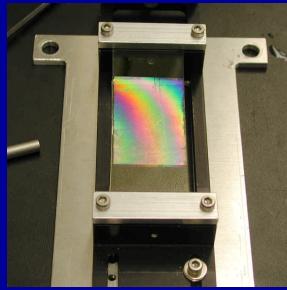
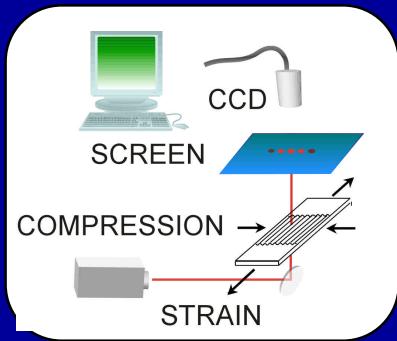
$$\text{Flexural Rigidity} ? Et^3$$

$$?_t ? \frac{E}{10}$$

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# Modulus of Thin Films



$$E_p \approx 4E_m (1 + \nu_p^2) \left(\frac{d}{2h}\right)^{1/3}$$

$E_p$  – modulus of the upper film  $d$  – buckling wavelength

$E_m$  – modulus of PDMS sheet  $h$  – thickness of upper film

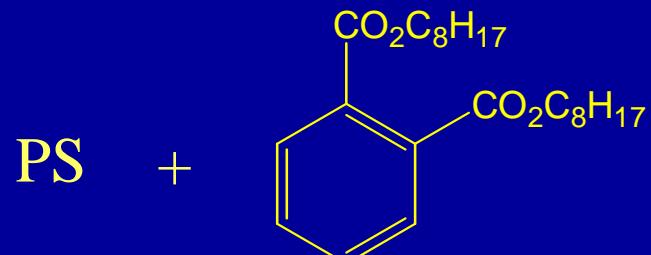
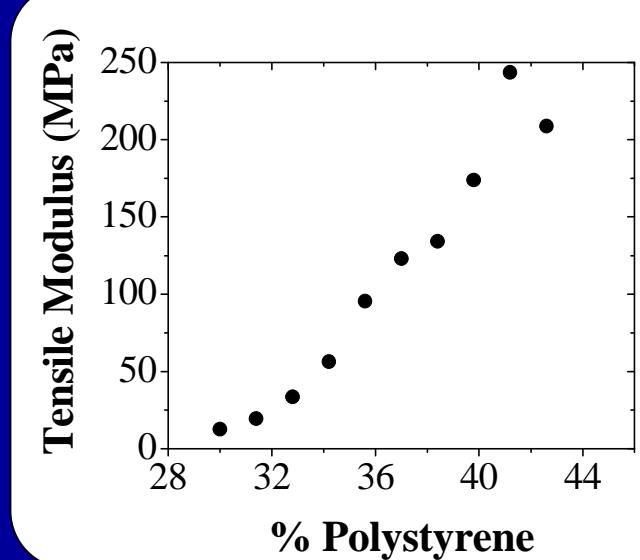
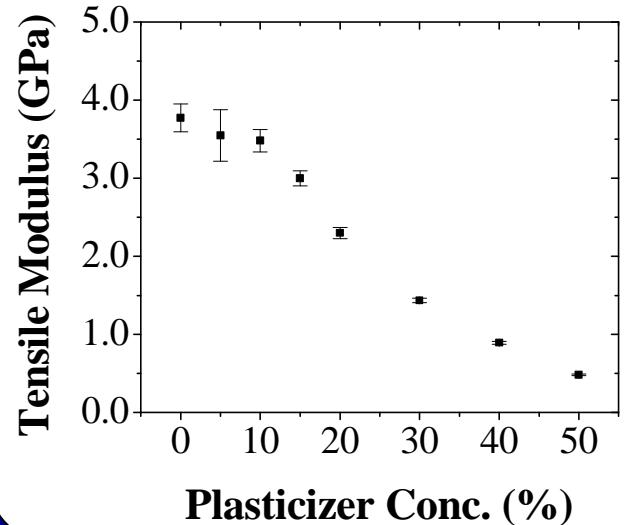
$\nu_p$  – Poisson's ratio of the upper film

Groenewold, J., *Physica A* 2001, 298, 32.

9.12.02



# *Modulus of Thin Films*

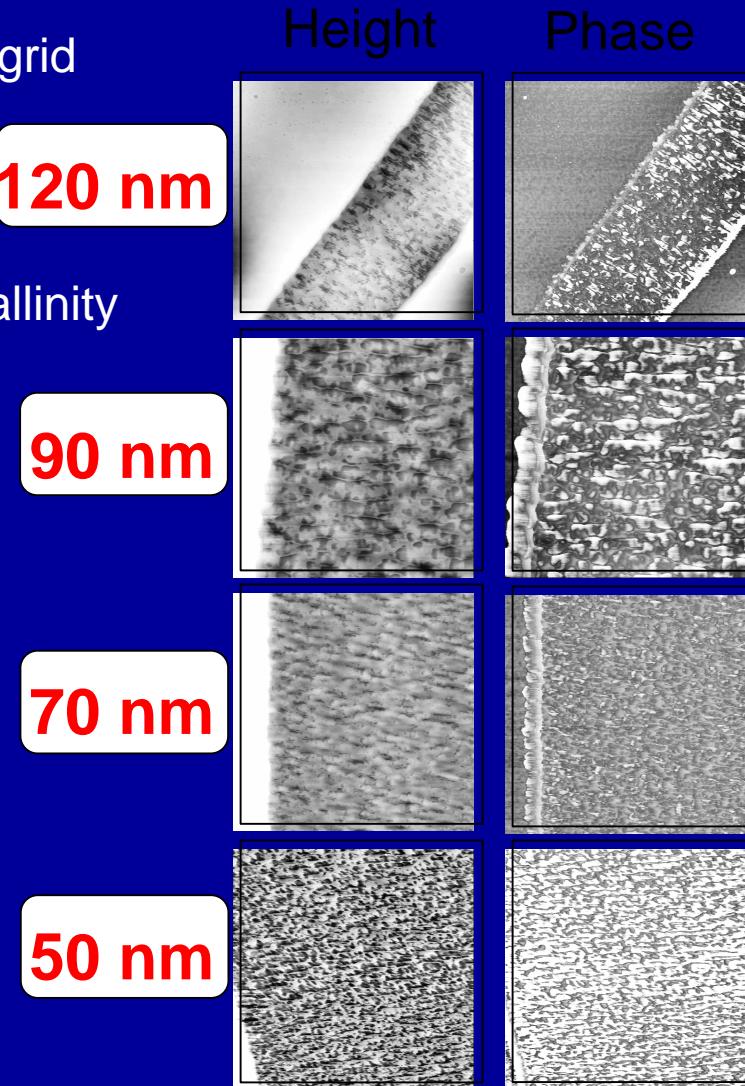
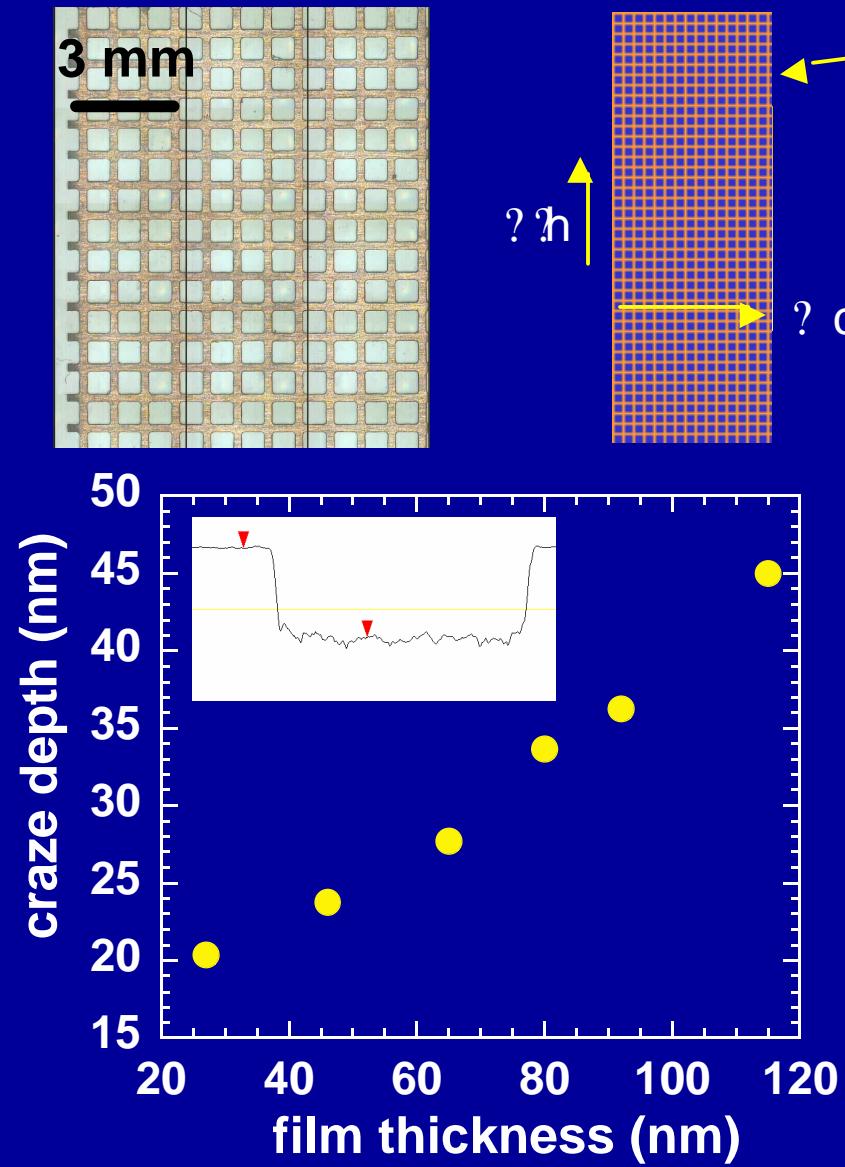


PS-PI triblocks  
(Vector 4215 & 4411)

PI – soft / rubbery  
PS – glassy

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# Combinatorial Crazing/Fracture



# *Modulus/Crazing*



## Future Directions FY03

- ✉ Prove robustness of modulus measurement.
  - ✉ UV-crosslinked systems
  - ✉ nanocomposites/nanotubes
  - ✉ thermal annealing / processing history
- ✉ Explore amplitude of buckling instabilities.
- ✉ Correlate AFM data on crack formation w/ light scattering data.
- ✉ Draw on craze/fracture skill set to better understand crack formation.
- ✉ Explore composition gradients.
- ✉ Open doors to other uses for this phenomenon.



# *Mechanical Properties*

Need:

❖ Develop simple yet reliable, high-throughput techniques by which material properties can be measured.

❖ Modulus  
❖ Strength  
❖ Viscoelasticity

❖ Creep  
❖ Toughness  
❖ Crazing / Fracture

etc.

Who Cares?

